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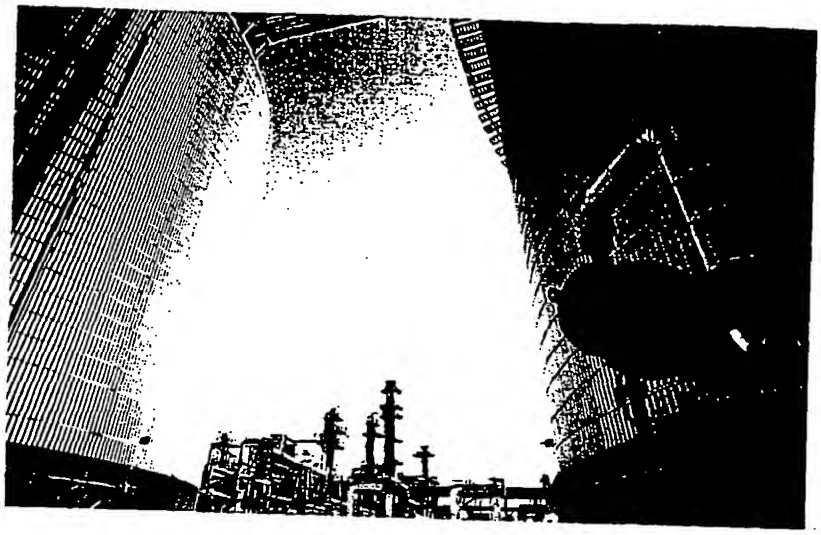


Amoco® polybutenes, also marketed under the name Indopol® polybutenes, are a family of viscous, non-drying liquid polymers. These isobutylene-butene copolymers are composed predominantly of high molecular weight monoolefins with minor isoparaffin content. The range of unique characteristics that result can be used to enhance and improve the performance properties of a wide variety of end-products in many different industries.

Polybutene

All grades of Amoco polybutene are colorless and exhibit little or no odor. They are chemically stable and resist oxidation by light and moderate heat. These products are permanently liquid and will not leave residue when volatilized or thermally decomposed. They are also hydrophobic and impermeable to water vapor or gas.

Among the important characteristics of Amoco's polybutene is the range of viscosities, from light to highly viscous fluids. Equally important, characteristics such as tackiness and molecular weight reflect the variation in viscosities among the different grades to help provide the characteristics you need for your particular application.

Hydrogenated polybutene

Amoco offers two grades of Panalane® hydrogenated polybutene (L-14E and H-300E). These liquid polymers are not readily oxidized, contain no cyclic compounds and impart no taste. They are miscible with a variety of mineral oils and organic solvents. Although hydrophobic, they can be easily emulsified.

Cust mer Supp rt

As the world's leading polybutene marketer, Amoco offers the security of assured supply from ISO 9002 certified, multiple manufacturing locations. Our extensive distribution network facilitates our ability to provide the polybutene grades you want in the quantities you need throughout the world. In addition, Amoco maintains a technically trained professional sales and research staff who work with you to provide sales and technical support and to assist you in the development of new commercial applications for polybutenes.

For current sales specifications, samples or additional information on polybutene applications, please refer to the available literature listing at the end of this brochure. For more detail on specific properties or uses of polybutene, please contact your Amoco sales representative or the nearest sales office listed at the end of this publication.

Amoco provides customer support from sales assistance in product selection and delivery through technical assistance in applications development.

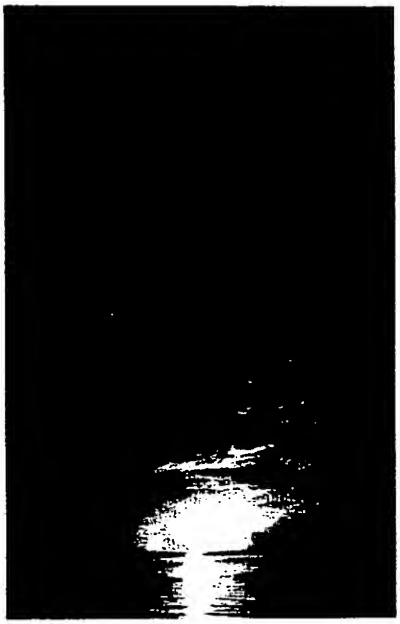
Health and Safety Information

The product(s) described herein may require precautions in handling and use. Material Safety Data Sheets (MSDS) for Amoco products are available upon request from your Amoco sales representative or by writing the address shown on this brochure. Always consult the Material Safety Data Sheet for products you consider using.

Responsible Car

Amoco Chemical Company is an active leader of the Chemical Manufacturers Association (CMA) Responsible Care initiative. The primary focus of the initiative is to improve the public's perception of the chemical industry, its products and performance through informed dialog and example.

Amoco Chemical has made Responsible Care a part of its key objectives by including it in its Management Principles.



Amoco's commitment to Responsible Care is demonstrated through the implementation of product stewardship and other codes of practice established by the Chemical Manufacturer's Association.

APPLICATIONS

The demand and uses for polybutenes continue to evolve as new applications are introduced and existing product lines are improved.

For example, since the last edition of this brochure, in 1990, the demand for polybutenes in polymer modification, gear oils, bearing lubricants, and metalworking fluids has increased. This is, in part, because of its non-staining and low carbon residue characteristics. Likewise, environmental demands have led to continuing development of products based on polybutenes, such as low-smoke, 2-cycle engine oils and waterborne emulsions for metalworking operations.

Food Contact –

Amoco polybutenes meet the requirements for food contact applications as defined by the U.S. Food and Drug Administration (Title 21, CFR 177.1430, 178.3570, 178.3910 and Title 40 CFR Part 180.1001). As such, they meet the requirements for use in a variety of food contact applications. A partial list is provided in Table 1.

These products are also included among products authorized by the United States Department of Agriculture (USDA) and appear on the "List of Proprietary Substances and Nonfood Compounds" among substances used in the preparation of product and nonfood compounds used in the plant environment. The U.S. Department of Commerce, National Marine Fisheries Service, recognizes this publication as an official list of nonfood compounds accepted for use in plants operating under that department's Fishery Products Inspection Program.

In addition, Amoco's polybutenes are kosher certified under the supervision of the Chicago Rabbinical Council and the United Orthodox Synagogues of Houston.

Table 1

FDA regulatory compliance (21 CFR)

		Polybutenes	Hydrogenated Polybutenes
Food contact			
175.105	component of adhesives	•	•
175.125	pressure sensitive adhesives	•	•
177.1430	indirect food additive: isobutylene-butene copolymers	•	
177.1520	plasticizer in polyethylene	•	•
177.1640	plasticizer in polystyrene	•	•
178.3740(b)	plasticizer in polymeric substances		•
178.3860	release agent in petroleum wax complying with 178.3710 and polymeric resins		•
178.3910	surface lubricant in the manufacture of metallic articles	•	•
Components of non-food articles			
175.300	resinous and polymeric coatings	•	•
175.380	resin component		•
175.390	coating component		•
176.170	paper and paperboard in contact with aqueous and fatty foods	•	•
176.180	components of paper and paperboard in contact with dry food	•	•
176.210	defoaming agents used in the manufacture of paper and paperboard	•	•
177.1210	closures with sealing gaskets for food containers		•
177.1350	ethylene vinyl acetate copolymers		•
177.2260(d) (2)	resin-bonded filters; substances employed in fiber finishes	•	•
177.2800	textiles and textile fibers	•	•
178.3570	lubricants with incidental food contact (provided that the addition of polybutene to food does not exceed 10 ppm)	•	•

Some other areas featuring polybutene-based developments include...

Agricultural Applications – Polybutene is used as a dust suppressant and to prevent caking in dry blend fertilizers. It is also used as an inert binder for active ingredients used in herbicides and pesticides (Title 40, CFR 180.1001(d).

Caulks & Sealants – The traditional benefits of polybutene in these products have been extended to include new interest in automotive sound-deadening in polyurethane and acrylic systems.

Coatings – Amoco's emulsion technology lets you formulate lower cost water-based wood and concrete sealers without loss of performance relative to commercial low VOC formulations.

Electrical – Just as polybutene has become a mainstay in copper cable flooding and filling compounds, technology advancements have sparked interest in polybutene materials by optical fiber bundle manufacturers.

Personal Care Products – Developments in sun-screens, creams and lotions, cosmetics, stick and roll-on antiperspirants, and other products based on Panalane® hydrogenated polybutenes have been commercialized.

Other improvements in resins for adhesives, films, textiles, molding compounds and other applications are just waiting for the advantages and solutions polybutenes can provide.

Lubricants and greases

Amoco polybutenes give superior all-around performance in a wide variety of lubricating applications. The water-white color and high viscosity of Amoco polybutene H-100 and H-300 grades permit the preparation of light colored, shear stable lubricants. These are often used for higher temperature/pressure operations like tube-drawing, casting, and forging.

The chemical stability of hydrogenated polybutene makes it ideal for hydraulic fluids and lubricants for fine instruments.

Low carbon residue

The non-staining and low carbon residue characteristics of polybutenes contribute to the performance benefits of lubricant formulations for gear oils, bearing lubricants and metalworking fluids.

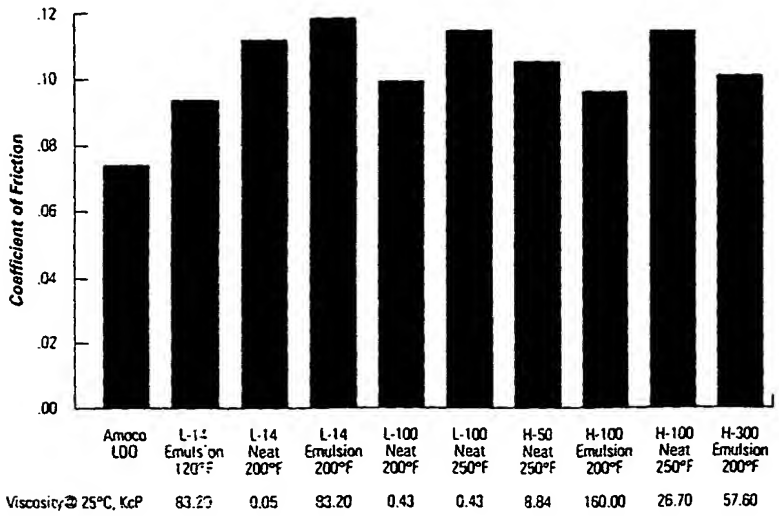
At moderate temperatures, polybutene behaves like conventional, high viscosity index, wax-free petroleum oils. Unlike conventional oils, however, polybutene depolymerizes at temperatures above its thermal decomposition point and disappears completely, leaving almost no carbon residue. The advantages of Amoco polybutene at high temperatures can be seen by the low Conradson carbon level (ASTM D189) noted in Table 2.

Amoco polybutene is suitable in many types of lubricating systems. It is recommended as a lubricant for oven and kiln bearings, especially the conveyer chains. The non-carbonizing properties of polybutene make it an excellent carrier for the graphite lubricant used in high temperature applications.

Scar diameters measured by the 4-Ball Wear Test (ASTM D4172) illustrate that neat polybutene (right) outperformed mineral oil (left).

FIGURE 1

Coefficient of Friction (ASTM D5183 mod.)



High shear stability.

Unlike many high molecular weight polymers, Amoco polybutene is not degraded by high shear. Tests have shown that polybutene grades from Amoco L-14 through H-1900 are as shear stable as any lubricant material of comparable molecular weight.

Sonic shear measurements have been shown to be related to mechanical shear. The data in Table 3 indicate that Amoco polybutene is resistant to shear degradation.

Excellent friction reduction

The higher molecular weight grades of Amoco polybutene have high viscosity indices and show excellent lubricating ability. Results of a four-ball wear test are shown in Table 4. The inherent lubricating ability of Amoco polybutenes is illustrated relative to a commercial oil in Figure 1.

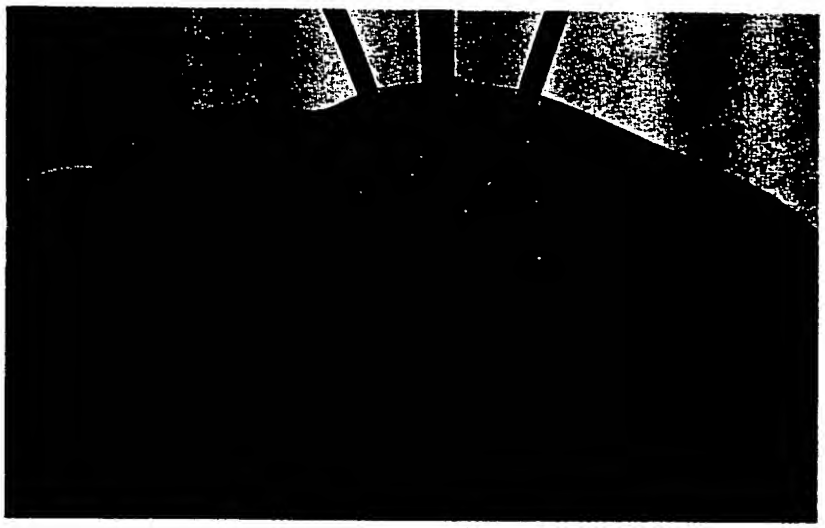


Table 2

Conradson carbon levels

	Carbon, wt.%
Amoco H-300 polybutene	< 0.01
SAE 50 motor oil base stock	0.5
Heavy lubricating oil (150–200 SUS at 99°F)	2.0

Table 3

Sonic shear stability[1]

	Initial viscosity at 38°C, cSt	Viscosity change, % 1 hour	2 hours
L-14	22.8	–1.5	–2
H-300[2]	68.5	0	0
H-1500[3]	62.9	–7	–6

[1] Data obtained using a *Raytheon* sonic oscillator model DF-101 at 0.7 radio-frequency amperes at 38°C using 50 ml samples.
[2] 23% Amoco H-300 in 5W oil.
[3] 14% Amoco H-1500 in 5W oil.

Table 4

Four-ball wear test

	Scar diameter, mm 1 hour	8 hours
Reference oil[1]	0.68[2]	1.20
Amoco L-50	0.57	0.78
Amoco H-100	0.60	–
Amoco H-1500	0.68	–

[1] Blend of 50% SAE-50 oil and 50% zero bright stock with viscosity equivalent of Amoco L-50.
[2] Rating scale: < 0.7 = excellent, 0.7–0.8 = good, 0.8–1.0 = fair, >1.0 = poor.

Metalworking lubricants

Neat polybutene, polybutene emulsions, and hydrogenated polybutene can be used as lubricants for metalworking. This includes can making, automotive applications (cutting, stamping, etc.), hot or cold rolling, tube extrusion, general metalworking, rust prevention, form-release, polishes, and waxes.

Both polybutene and hydrogenated polybutene can be emulsified for use with non-ferrous metals. Test results, illustrated in Figures 2 and 3, show that both polybutene and polybutene emulsions were equal to, or out-performed, a comparably viscous mineral oil (74 cSt @ 40°C; 380 SUS @ 100°F) in 4-ball Wear and Pin and V-block lubrication. Typically, emulsions are preferred where large quantities of frictional heat must be removed by water.

Broad application advantages

Blends of Amoco polybutene with co-lubricants like esters, mineral oils or fatty acids have also demonstrated superiority in lubrication for hot or cold rolling and drawing of metal sheet, wire and tube. For example, a typical drawing oil compound uses 5 to 20 percent stearic acid as a wetting agent in polybutene, with 0.02 percent benzotriazole added as a metal deactivator in non-ferrous material.

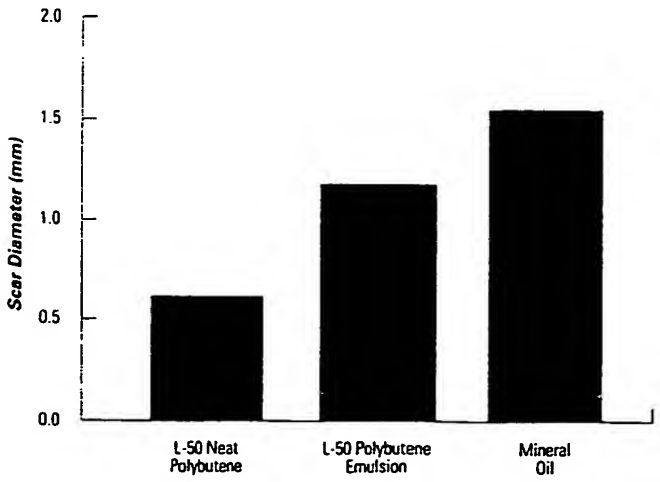
Panalane hydrogenated polybutenes can be used in metal forming lubricants and, like neat polybutene, can be emulsified for use in forming non-ferrous metals. Lubricants containing hydrogenated polybutene can meet U.S. FDA specifications for use in the manufacture of metal foils and cans designed for food contact.

Food contact applications

Surface lubricants containing polybutene can meet the requirements of the U.S. Food and Drug Administration (Title 21, CFR 178.3570) for incidental food contact and (Title 21, CFR 178.3910) as surface lubricants used in the manufacture of metallic articles that may come in contact with food. They also appear on the USDA "List of Proprietary Substances and Nonfood Compounds". This publication lists proprietary substances used in the preparation of product and nonfood compounds used in the plant environment which are authorized by the Food Ingredient Assessment Division (FIAD), Science, Food Safety and Inspection Service (FSIS), for use in slaughtering and processing plants operating under the USDA poultry, meat, rabbit, shell egg grading, and egg products inspection programs. Polybutenes are

FIGURE 2

Four-ball wear test (ASTM D4172)



Polybutene emulsions provide an effective route to metalworking fluids that meet VOC requirements.

The inherent EP properties of polybutene emulsions make them desirable in working with aluminum and other nonferrous metals in a variety of applications.

included under Category H1 (for use as a lubricant, release agent or antirust film on equipment and machine parts in locations where there is exposure of the lubricated part to edible products).

The U.S. Department of Commerce, National Marine Fisheries Service, recognizes this publication as an official list of nonfood compounds accepted for use in plants operating under that department's Fishery Products Inspection Program.

Long shelf life and low unsaturation level make Amoco hydrogenated polybutene a good choice for food contact applications. Its chemical stability makes it ideal for hydraulic fluids and lubricants for fine instruments. This is applicable, for example, in can forming operations for food and beverage containers which require a clean, non-oxidizing lubricant with low odor and no taste. Polybutenes, including hydrogenated polybutene and polybutene emulsions, can be used in the production of aluminum and steel foils.

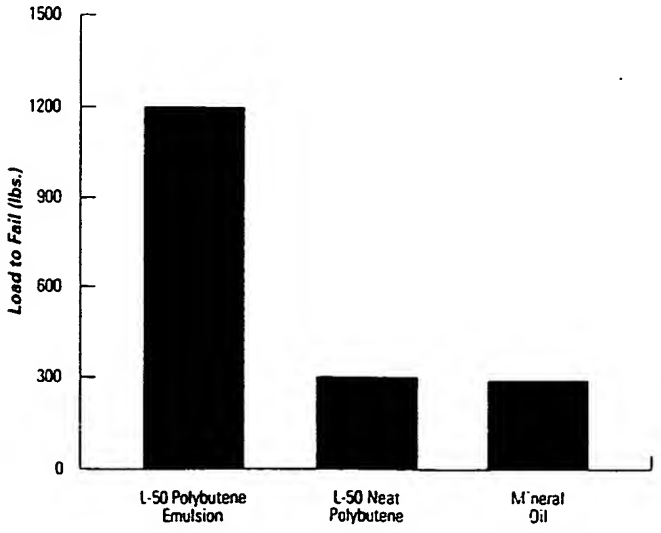
Emulsion technology

Recent research by Amoco has demonstrated that stable polybutene emulsions can be formulated for use in metalworking and other applications. Polybutene emulsions do not need solvents for cleaning and therefore help reduce VOC emissions. They can be formulated with biocides, corrosion inhibitors, coupling agents and demulsifiers to obtain the performance characteristics you need. The inherent extreme pressure (EP) properties of polybutene emulsions make them particularly beneficial for working with aluminum. Other EP additives can be incorporated to optimize specific formulation performance.

Polybutene emulsions can be used for drawing and ironing applications including can-making. Since water and surfactants present in some emulsions may cause stains, individual applications may require evaluation of special surfactants if staining is a concern.

FIGURE 3

Pin and V-block test



High temp rature applicati ns

One unique advantage of neat polybutene is that it reduces stains and leaves no residue on metals after annealing or similar high-temperature operations are performed. Unlike conventional lubricants which must be removed before heating, neat polybutene depolymerizes when heated above 270°C (518°F)[1] without leaving deposits or stains. The elimination of the degreasing step can help reduce processing costs.

For high temperature applications using graphite, polybutene has served as a carrier/co-lubricant. At controlled temperatures in these applications, polybutene decomposition can be slow enough to provide the necessary lubrication. A literature source suggests that graphite works better in the presence of water and oxygen, thus suggesting that polybutene emulsions would also perform well in these applications. Graphite can be dispersed in polybutene emulsions.

Other applications

Sulfurized polybutene is suggested as an additive in mineral-based cutting oil formulations. Sulfurized polybutene is free of polycyclic aromatics and is more soluble than conventional additives.

Soap-based gels/greases

Amoco polybutene may be converted to a gel by incorporating a metal soap such as aluminum stearate. Gels made from lower molecular weight grades are made by heating the soap slurry in the polybutene to about 200°C, stirring, cooling rapidly and homogenizing. Higher molecular weight grades may require from 0.5 to 20 percent diglycol stearate, hydrogenated fatty acid or lauryl alcohol to aid in mixing.

Greases can be made using polybutene with calcium, lithium or aluminum soaps in a heated grease mixer for use in plain and anti-friction bearings. The grade of polybutene used contributes to the consistency of the grease and, more importantly, provides protection against water wash-off. This is especially important in greases for heavy-duty construction equipment, fifth wheel, chain drives, and other applications requiring a grease that clings to metal and resists spin-off.

Two-cycle engine oils

In many motorcycle engines, the fuel/oil ratio is set to meet the most severe operating conditions. This results in high consumption of oil. It can also lead to blocking of exhaust ports, fouling of plugs, and heavy deposits in the combustion chamber. Frequently, large amounts of oil do not burn and are released in the pungent smoke associated with two-stroke engines, contributing to visible haze and air pollution.

Use of Amoco polybutenes as a component in two-cycle engine oils (also known as 2-stroke or 2-T oils) can effectively reduce these visible emissions. As with metalworking fluids, the oil burns more cleanly and efficiently, without reducing engine power. The polybutene oil blend forms a stable film that provides good internal lubrication, thereby improving the cleanliness of the engine and exhaust ports.

Polybutene provides tack and protects against wash-off of greases on exposed gears of construction equipment.

[1] Depolymerization becomes rapid above 350°C (660°F).

Hydrogenated Polybutene

Amoco polybutene can be hydrogenated to produce a liquid polymer which does not readily oxidize. Hydrogenated polybutene contains no cyclic compounds and imparts no taste. It is miscible with a variety of mineral oils and organic solvents. Although it is hydrophobic, it can be easily emulsified.

There are two grades of Amoco hydrogenated polybutene, L-14E and H-300E. Physical properties are listed in Bulletin HB-4 .

Panalane L-14E for cosmetics – This product *(CTFA: hydrogenated polyisobutene)* is a hydrogenated grade of polybutene specifically designed for cosmetics and personal care applications. It is a bright, clear, viscous liquid with outstanding feel, waterproofing properties, and moisturizing ability. This makes it ideal for use in sunscreens, lip preparations, eye shadow, stick and roll-on antiperspitants, creams and lotions and other quality products.

Laboratory tests show Panalane L-14E to be non-irritating to eyes and skin, non-comedogenic, and nontoxic when ingested. A description of experimental conditions and a list of test results are provided in Bulletin HB-5 which is available from your Amoco sales representative.

The high quality of Panalane L-14E makes it a candidate to replace squalane, fatty esters, and other expensive oils used in cosmetics. Its economical price allows it to upgrade the quality of cosmetics currently formulated with mineral oils. For sample formulations, ask for Bulletins HB-6 and HB-7.

Panalane hydrogenated polybutene provides "Smoothness on a scale you've never seen before" in creams, lotions and other personal care formulations.

Caulks and sealants

Most major manufacturers of caulks and sealants use Amoco polybutene as the primary vehicle or as a modifier. Water-white color, chemical inertness, tackiness, permanence, low density, and consistency make Amoco polybutene an attractive component of many quality sealant formulations.

Amoco laboratories have carried out extensive research on the use of polybutene in caulks and sealants. Amoco laboratories offer technical service on developing new formulations, improving existing ones, testing, and evaluation. For sample formulations developed by Amoco, ask for Bulletin 12-4.

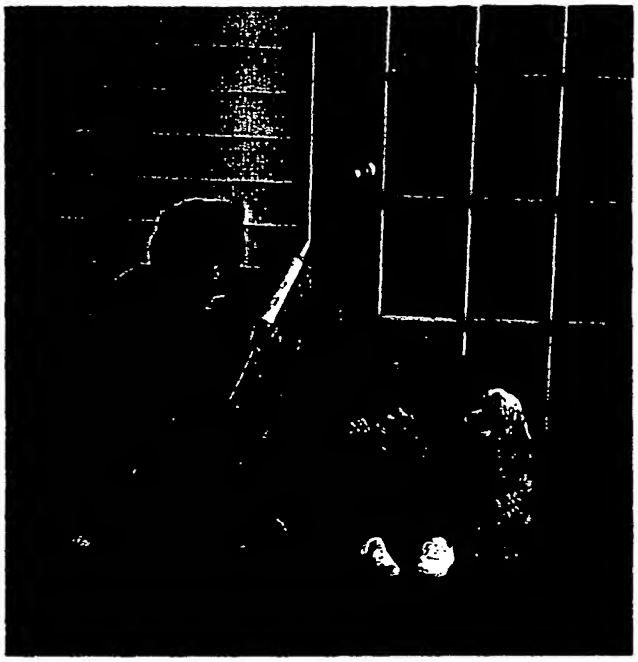
Caulks

The heavier grades of Amoco polybutene act as the primary vehicle in conventional drying oil putties by providing the necessary adhesion and pliability. The lighter grades of polybutene can replace mineral spirits to minimize evaporative shrinkage and adhesion loss.

Manufacturers of high quality gun caulks use Amoco polybutene to extend shelf life, improve antislump properties, stabilize viscosity over a wide temperature range, provide permanent pliability, improve resistance to cracking and age-hardening, give good oil retention, and ensure good color and color stability.

Clear sealants

Clear sealants based on Amoco polybutene have outstanding peel adhesion and good aging. These sealants are also more translucent than commercial silicone, acrylic, or thermoplastic elastomer sealants. Polybutene contributes superior lap shear properties and lower material costs.



Polybutene provides an array of desirable characteristics to caulks and sealants for home and commercial use.

Rubber-based s alants

Medium to high molecular weight polybutene can extend, tackify and plasticize durable sealants based on elastomers such as styrene-butadiene rubber[1] and polyisobutylene.[2]

Polybutene improves tack adhesion, pliability and sealant processing. It can alleviate shrinkage by partially replacing volatile materials used with nonvulcanized butyl rubber. Using polybutene as a mixing base for the sealant compound minimizes mechanical breakdown of the rubber during blending.

Hot-melt sealants based on butyl rubber[3,4] can be used to seal concrete. They are also useful for sealing boxboard and as a caulk or glazing compound.

Sealants and glazing compounds made from polyurethane[5] can be used for thermal insulated architectural glass. Tape sealants used to seal edges of automotive glass can be made from natural rubber[6] or butyl rubber.[7]

TPE-bas d sealants

Sealants based on thermoplastic elastomers are another area where Amoco polybutene adds advantages. Sealants based on butadiene-ethylene-styrene triblock copolymers[8] or ethylene-propylene terpolymers can be plasticized with polybutene.

Thermoplastic domains in the elastomer chains provide flow while the elastomeric portion provides the effect of vulcanization. Large amounts of high molecular weight polybutene can be used to plasticize and tackify the hot-melt sealants while reducing raw material costs.

For sample formulations developed by Amoco, ask for Bulletin 12-4.

[1] Richard C. Doss. *Applying Sealant Composition.* US patent 4113914 assigned to Phillips Petroleum Co., 1978.

[2] *Composite Sealing Material.* JP patent 57/610077 assigned to Bridgestone Tire Co. Ltd., Hayakawa Rubber Co. Ltd. and Ito Shoji Co. Ltd., 1982.

[3] *Sealants for Concrete Joints.* JP patent 58/38779 assigned to Hayakawa Rubber Co. Ltd., 1983.

[4] Edward F. Kutch et al. *Hot-Melt Sealants, Adhesives and the Like.* US patent 3932341 assigned to Novagard Corp., 1976.

[5] Floyd Wilson, Jr. *Insulated Glass and Sealant.* US patent 4153594 unassigned, 1979.

[6] Osamu Sano et al. *Laminated Glass Panes.* JP patent 62/265148 assigned to Aisin Kako Co. Ltd., 1987.

[7] Robert M. Myers et al. *Joint Sealant for Automobile Windows.* FR patent 2321582 assigned to Novagard Corp., 1977.

[8] Larry F. Leicht. *Thermally Applied Sealants and Process.* US patent 4677133 assigned to O'SO, Inc. 1987.

Adhesives

Amoco polybutenes are vital ingredients in many pressure-sensitive adhesives (PSA) and hot-melt adhesives (HMA). They exhibit permanent tackiness and are compatible with many resins, elastomers, and solvents. In addition, they offer good color, as well as oxygen and chemical resistance.

For sample formulations of pressure-sensitive and hot-melt adhesives based on polybutene, ask for a copy of Bulletin 12-32.

Pressure-sensitive adhesives

In laboratory studies of PSA's, polybutene improved the quick stick and peel strength of elastomers such as polyisobutylene, styrene-isoprene-styrene block copolymers, and styrene-butadiene rubber. Polybutene improved the tack of styrene-butadiene-styrene block copolymer, natural rubber and synthetic rubber. Raw material costs can be lowered as polybutene partially replaces tackifiers used in pressure-sensitive adhesive formulations.

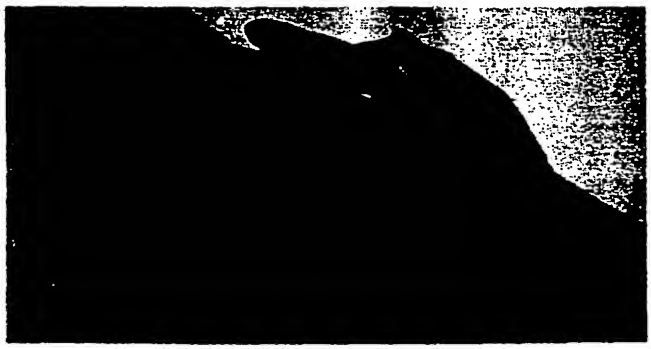
Examples of these adhesives which are improved with polybutene include: pressure-sensitive adhesives for paper laminates, labels and tapes; masking and friction tapes; surgical tapes; colorless adhesives; cements for leather; paper, foil and fiber lamination; and industrial tapes.

Nonionic polybutene emulsions decrease the organic vapor emissions in water-based pressure-sensitive adhesives. The emulsions offer enhanced adhesion and temperature stability while lowering costs in adhesives for packaging, labels, and product assembly.

Hot-melt adhesives

When incorporated into hot-melts, polybutene acts as a polymer extender, plasticizer, tackifier, and wetting agent. Using polybutene decreases the melt index and increases the cold temperature flexibility. Compatible adhesive resins include butyl rubber,[1] styrene-isoprene-styrene copolymer,[2] ethylene vinyl acetate,[3] polyurethane,[4] and low density polyethylene. The major applications for these hot-melt adhesives include packaging, disposable soft goods, bookbinding, carton sealing, carpet, shoes, and furniture.

In multilayer food packaging applications, a barrier resin bonds to a substrate which can be rigid or flexible. Coextrusion of the adhesive tie layer, barrier resin, and substrate bonds the dissimilar resins during processing. Polybutene improves the tack and adhesion of the tie layer formulations while reducing formulation costs. Food packaging applications using a hot-melt extrudable adhesive include cups, trays, plates, bags, and lid films.



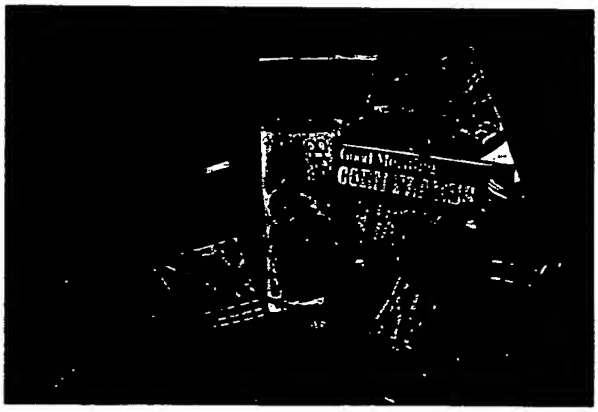
[1] *Hot-Melt Compositions Based on Crosslinked Butyl Rubbers.* GB patent 1541609 assigned to Evode Ltd., 1979.
[2] Toshio Okuyama et al. *Hot-Melt Adhesives for Polypropylene.* JP patent 63/213586 assigned to Toa Gosei Chemical Industry Co. Ltd., 1988.
[3] David F. O'Sullivan. *Hot-Melt Adhesive Compositions.* GB patent 2197326 assigned to Swift Adhesives Ltd., 1988.
[4] Akio Ogata et al. *Polyurethane-Based Hot-Melt Adhesives.* JP patent 63/120785 assigned to Yokohama Rubber Co. Ltd., 1988.

H t-melt pressure-sensitive adhesiv s

Amoco polybutene plasticizes many elastomers used in hot-melt pressure-sensitive adhesives, . . including natural rubber,[1] styrene-butadiene rubber,[2] alphaolefin,[3] and butyl rubber.[4,5]

Polybutene enhances the tack and quick-sticking properties of thermoplastic elastomers which exhibit negligible inherent tack. Adjusting the relative concentration of polybutene can tailor hot-melt pressure-sensitive adhesive systems for a variety of end uses.

Long recognized for its characteristic tackiness, polybutene offers improved adhesion and chemical resistance in hot-melt and pressure sensitive applications.



[1] Ivan J. Balinth. *Pressure-Sensitive Adhesive Compositions Having High Shear and Low Peel Resistance.* US patent 4335026 assigned to Johnson and Johnson Products, Inc., 1982.
[2] Akihiro Yamazaki. *Strippable SBR-Based Adhesives.* JP patent 63/135472 assigned to Mitsui Toatsu Chemicals, Inc., 1988.
[3] Jimmy R. Trotter et al. *Hot-Melt, Pressure-Sensitive Adhesives.* EP patent 3194 assigned to Eastman Kodak Co., 1979.
[4] *Sealing Tapes.* JP patent 59/20701 assigned to Nitto Electric Industrial Co. Ltd., 1984.
[5] Michael J. Gerace et al. *Coated Bonding Tapes Having Improved Peel Strength Combined With Low Temperature Flexibility.* WO patent 84/130 assigned to Protective Treatments, Inc., 1984.

Cling films

Adding 3 to 6 percent Amoco polybutene to linear low density polyethylene (LLDPE) resin imparts excellent cling to stretch wrap film. Polybutene can improve resin melt flow and film properties such as elongation, tear resistance, haze, Spencer impact strength and low temperature flexibility. These advantages have been observed in both blown film and slot cast film and in both 1-butene and 1-octene LLDPE resins. For details on cling films, ask for Bulletin 12-34.

Th rmoplastic and rubber modifier

Hydrogenated polybutene meets U.S. FDA specifications for use with polyethylene and polystyrene polymers in food contact applications (Title 21, CFR 178.3740). Amoco hydrogenated polybutene provides improved color stability over polybutene, making it suitable as a lubricant for thermoplastics and cling additive for stretch wrap film.

Coatings and sealers

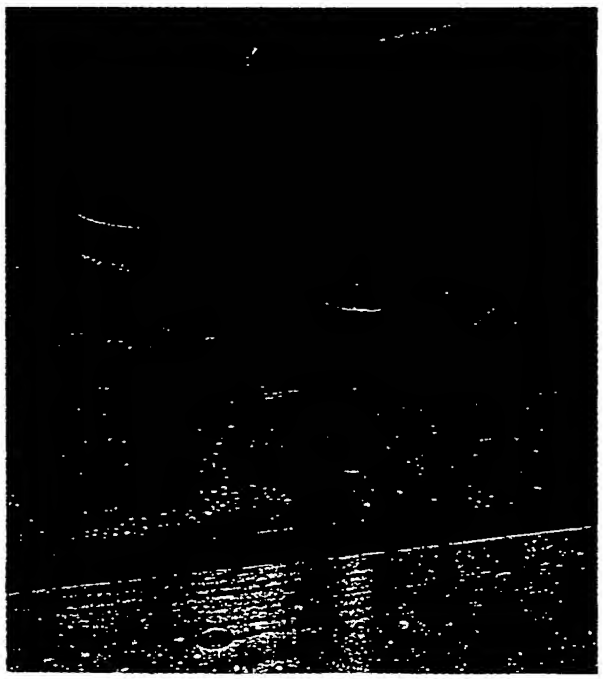
Polybutene has been a successful component in special purpose paints and coatings. Application of Amoco's recently developed polybutene emulsion technology has been suggested for additives and modifiers of a variety of water-borne coatings. Light color, water resistance, and plasticization of the final film are among the potential advantages of Amoco polybutene.

When applied to porous substrates such as wood or concrete, solvent-based formulations and emulsions of Amoco polybutene provide waterproofing protection. They reduce swelling, shrinkage and splitting of wood and protect against freeze-thaw cracking, salts, and chemicals on brick or concrete.

Hydrogenated polybutene improves the performance of cling film and adds other benefits to thermoplastics used in food contact applications.

Emulsion-bas d wood and concrete sealers

Polybutene emulsion formulations offer potential to lower manufacturing costs and improve water repellency relative to commercial acrylic-based systems. Low VOC (<400g/L) polybutene emulsion starting formulations (solvent <5% by weight) have been demonstrated for wood and concrete sealers. Viscosity grades of Amoco L-65 through H-300 were used to provide formulations which range between 10% to 20% nonvolatile material (NVM). Test results indicate these preliminary laboratory formulations provide water repellency comparable to commercial low VOC systems. Optimization of these formulations could result in improved performance at lower costs than current commercial products.



Recent work in Amoco's technical service laboratories demonstrates the ability of polybutene emulsions to lower manufacturing costs and improve water repellency in wood sealers.

Other seal rs

Polybutene emulsion sealers can also be used in concrete form release and are candidates for bond breakers used in tilt-and-lift construction. They can also be tailored for use on fabrics such as shoes, backpacks, and tents.

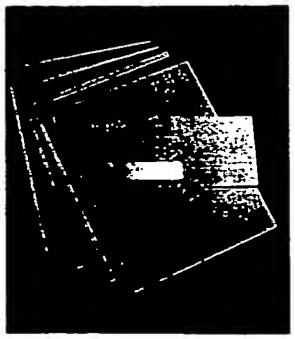
Paper treatments

Paper can be made moisture and vapor resistant by treating with emulsions of Amoco polybutene and a variety of materials such as latex, alkyd-coumarone indene and rosin ester dispersion, asphalt emulsions, or acrylic and methacrylate polymer and copolymer emulsions. These treated papers are flexible and offer excellent physical and optical properties.

Crystalline waxes and brittle microcrystalline waxes used for paper coatings can be toughened and plasticized by blending with polybutene. The sealing strength and melt viscosity of the waxes can be substantially increased.

Amoco L-14 polybutene has served as a replacement for paraffin wax and mineral oil to improve the quality of carbon papers. It considerably improves pigment wetting, leaving a blacker impression and giving a sharper, clearer print. Polybutene also imparts a drier feel to the paper, thus preventing sticking of one sheet to another.

Paper products that use polybutene laminating compounds can have better adhesion, lighter color and greater color stability.



Resin plasticizer and process aid

The impact strength, flexibility, and melt flow rate of many thermoplastic resins are increased with Amoco polybutene. Polybutene plasticizes polypropylene, polystyrene, ethylene-vinyl acetate copolymer,[1] modified resins, ester gums, and polyterpene. Amoco polybutene meets U.S. FDA specifications for plasticizers used in polyethylene and polystyrene polymers for food contact (Title 21, CFR 177.1430).

In crystal polystyrene, polybutene improves flow and impact strength better than mineral oil while maintaining higher strength and deflection temperature. Impact polystyrene formulated with polybutene offers better tensile strength, tear resistance, and impact strength.

Polypropylene homopolymers modified with polybutene have higher melt flow rates, greater elongation, and improved Gardner impact strengths. In filled and reinforced polypropylene polybutene can be used to "wet" the fillers and aid processing. In polypropylene film applications, polybutene can improve tear resistance and clarity, as well as impact and elongation properties. Film impact resistance can be improved by 60-100% by incorporation of polybutene.

Polybutene has been used in ethylene-propylene diene monomer(EPDM)/polypropylene compounds to increase impact strength at slightly lower compound costs. These materials are useful as roofing compounds.

For details on using polybutene in processing polypropylene and polystyrene, ask for Bulletin 12-35.

Polybutene plasticizes thermoplastics and rubber compounds and provides improvements in flexibility, impact strength and other properties.

[1] Karel C. Janac et al. *Blends of Polyolefin Plastics With Elastomeric Plasticizers.* EP patent 92318 assigned to Exxon Research and Engineering Co., 1983.

Rubber modifier

Amoco polybutene is an exceptionally permanent extender and plasticizer for a variety of vulcanized elastomers including natural rubber, butyl rubber, polyisoprene, polybutadiene, ethylene-alpha-olefin rubber[1] and styrene-butadiene rubber (SBR). For sample rubber formulations, ask for Bulletin 12-30.

Roofing and pipe wrap compounds made from butyl rubber or EPDM-modified butyl rubber can be plasticized with Amoco polybutene. These compounds show excellent tensile strength, elongation, low temperature flexibility and UV stability.

Amoco polybutene is compatible with the elastomeric portion of thermoplastic block copolymers such as butylene-ethylene-styrene block copolymer.[2] In low concentrations, polybutene softens and plasticizes thermoplastic elastomers. At higher levels, polybutene contributes tack and adhesion.[3]

Laboratory tests have shown that rubber compounds containing polybutene are resistant to extraction and degradation by solvents and to exudation by heat aging. In white or light-colored stocks, polybutene provides superior color stability in ultraviolet light and heat aging.

Unlike mineral oil, polybutene cannot be easily extracted from vulcanized elastomers by solvents. It has been suggested that the permanence of polybutene may be due to a physical or chemical linkage with elastomers during vulcanization. The terminal unsaturated groups in polybutene may react with sulfur or with elastomeric double bonds during cure.

[1] *Heat Stable Rubber Blends.* JP patent 56/118440 assigned to Mitsui Petrochemical Industries Ltd., 1981.
[2] John Y. Chen. *Gelatinous Elastomeric Optical Lens, Light Pipe, Comprising a Specific Block Copolymer and an Oil Plasticizer.* US patent 4618213 assigned to Applied Elastomerics, Inc., 1986.
[3] Zenzo Shimogo et al. *Self-Bonding Shock Absorber Sheets.* WO patent 86/2657 assigned to Aisin Industry Co. Ltd. and Toyota Motor Co. Ltd., 1986.

Asphalt modifier

Asphalt compounds plasticized with polybutene are claimed to be a more durable paving material.

Automotive underc at

Automotive undercoatings which deaden sound and protect against corrosion are sometimes based on an asphaltic base. The addition of Amoco H-100 polybutene will improve low temperature flexibility and adhesion. The undercoat must be applied to a clean, dry surface to ensure good adhesion.

Asphalt and TPE rubber

Asphalt emulsions with rubber latex can be plasticized with polybutene emulsions.[1] These materials are quick drying and have good cold crack resistance.

When combined with alpha-methylstyrene polymers, asphalt/TPE rubber goods plasticized with Amoco polybutene have excellent tensile strength and tear resistance.

The composition of the asphalt plays a large role in final properties. In general, lower aromatic content and higher naphthenic content produces better results.

Asphalt compounds containing polybutene demonstrate improved low temperature flexibility and are ideal for use as crack fillers in road repair.

Preparation of Water-Proofing Coating Composition for Concrete etc. by Blending Asphalt Emulsion With Rubber Latex or Synthetic Resin Emulsion, Polybutene Emulsion and Cement. JP patent 57/16070 assigned to Nippon Oils and Fats KK, 1980.

Electrical insulation

Amoco polybutenes are nonconductive and ideally suited for a variety of electrical applications. Their chemical structure and low chloride content, as well as low levels of sulfur, nitrogen, metals and other impurities, make Amoco polybutenes highly resistant to oxidation and gas evolution under electrical stress. Their small increase in power factor on aging and their outstanding resistance to oxidation enables Amoco polybutenes to give superior performance.

Impregnant for dielectrics

One of the early uses of Amoco polybutene was as a paper and fabric impregnant for wire insulation. The insulation may be applied in tape form, with glass or quartz fibers embedded in the solid polybutene.

Cable oils

Pipe oils in extremely high voltage conductors can be made from Amoco polybutene. Because of its low chloride content and power factor stability, Amoco polybutene was selected as the primary pipe oil for the first commercial underground 345kV transmission line.

Cabl insulation

When combined with a halogenated flame retardant, butyl rubber[1] plasticized with polybutene can be used as an electrical insulator.

Foamable polyethylene plasticized with polybutene can also be used as an insulator.

Polytetrafluoroethylene (PTFE) films or fabrics of glass or other inorganic fabric treated with PTFE can be coated on one side with a pressure-sensitive adhesive based on polybutene. These fabrics can be used to form anticorrosive, antistick insulations.

Polybutene compounds insulate and provide oxidation resistance in electrical applications such as cable filling and flooding compounds.

[1] Shunichi Takai et al. *Butyl Rubber Compositions for Electric Insulators.* JP patent 50/77448 assigned to Fujikawa Electric Co. Ltd., 1975.

Polybutene/polyolefin blends

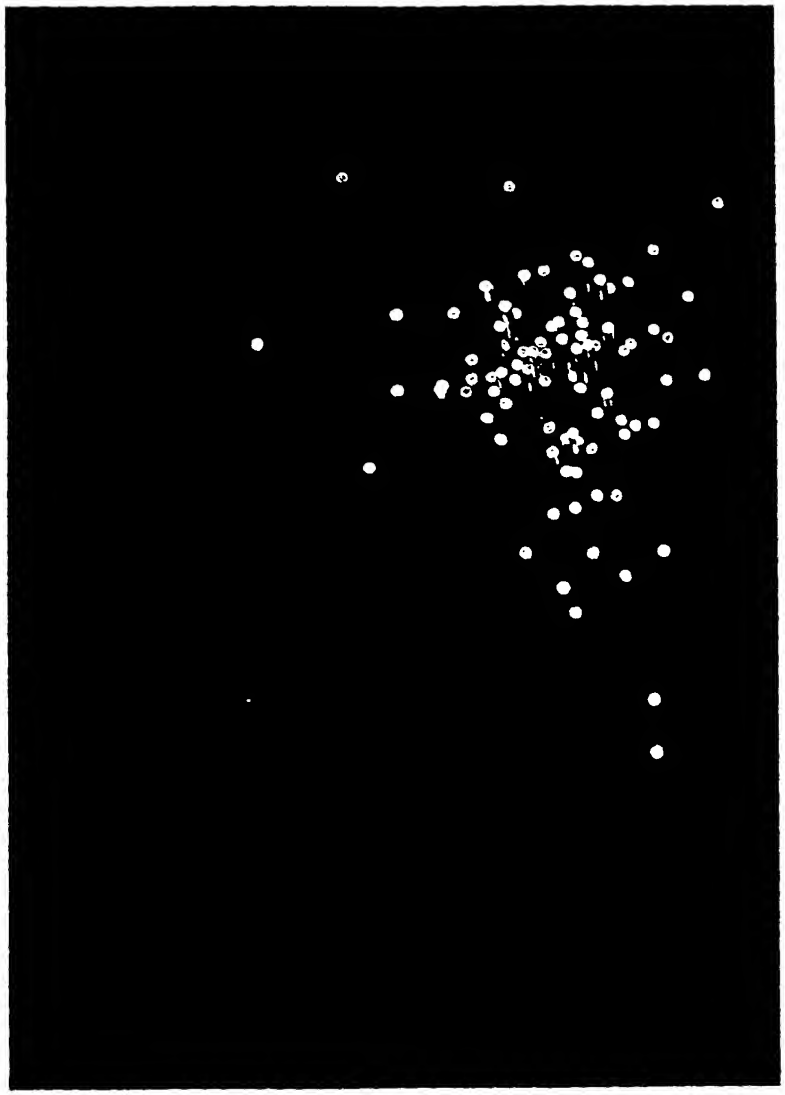
Blends of polybutene and polyolefins produce semi-solid gels which can be used as potting compounds and cable flooding and cable filling compounds.

BR-310 cable flooding compound

Amoco BR-310 acts as a moisture barrier and corrosion inhibitor when used to flood the area between the layers of composite metal-plastic sheath in electrical cables. The adhesive quality of Amoco BR-310 prevents slippage between layers of the cable sheath.

CI-500 cable filling comp unds

Amoco CI-500 is a high quality filling compound that acts as a moisture barrier and corrosion inhibitor when added to a cable core containing paired wires. It is also used to fill the interstitial space in the core and is compatible with most cable flooding materials.



Technical advancements have sparked interest in polybutene materials for insulating optical fiber bundles.

Leather impregnants

Shoe sole leathers impregnated with combinations of polybutene and resins have increased resistance to water and wear. The improved flexibility also facilitates shoe making operations such as trimming and stitching. The degree of improvement in wear and water resistance is dependent on the amount of impregnant deposited in the leather.

Leather impregnated with polybutene is a popular material for sports grips for golf clubs, tennis racquets and gear shift knobs. The permanent inherent tackiness of polybutene provides significant performance advantages for these applications.

Polybutene combined with paraffin wax and polymerized rosin can produce hot-melt impregnants. This material is claimed to give resistance to vesicants and to improve wear and water resistance.

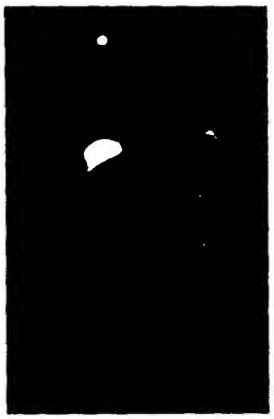


FIGURE 4

Structure of Amoco polybutene

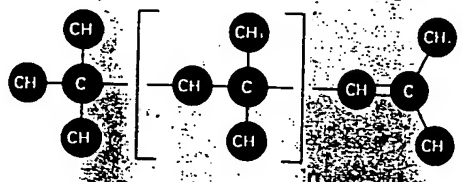


FIGURE 5

Derivative of maleic anhydride and polybutene

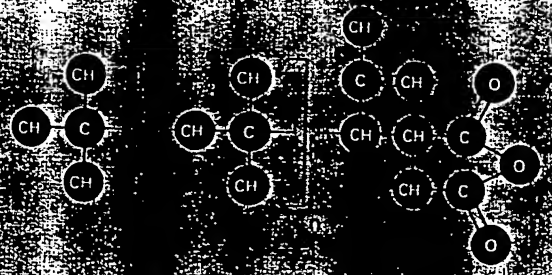
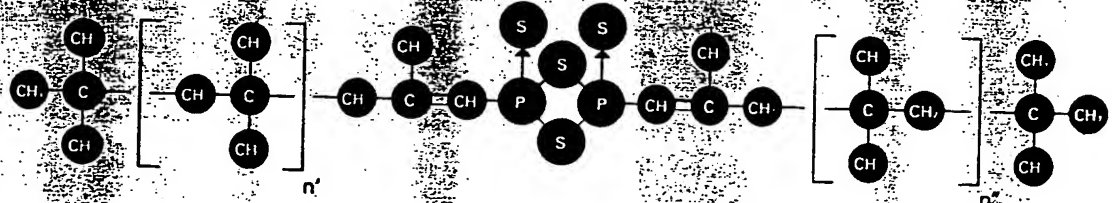


FIGURE 6

Derivative of phosphorus pentasulfide and polybutene



Derivation

Amoco polybutenes are made by polymerizing an isobutylene rich butene stream over a catalyst. The polymer is an aliphatic olefin similar to polyisobutylene although some 1- and 2-butenes are incorporated. The major component of polybutene is shown in Figure 4. Some internal double bonds probably exist, but these are difficult to characterize.

Reactivity

The structure of Amoco polybutene offers an interesting backbone for the synthesis of derivatives with special properties. The oleophilic or hydrophobic nature of the molecule can be exploited in making detergents or antirust additives. The molecule contains an isolated double bond (see Figure 4) which makes it more chemically stable than highly unsaturated mineral oils. Therefore, polybutene is resistant to physical or chemical changes caused by aging.

Derivatives of polybutene can be made by the chemical reactions common to aliphatic mono-olefins. Addition of various reagents to the double bond can occur by free-radical or ionic mechanisms, as in the addition of chlorine or hydrogen bromide or in the alkylation of isoparaffins or aromatics.

The alpha position to the double bond is also reactive and adducts can be readily produced.

Polybutene derivatives of maleic anhydride and phosphorus pentasulfide are shown in Figures 5 and 6.

Amoco Chemical also manufactures hydrogenated polybutene (in which the double bond has been saturated) and polybutene/polyolefin blends used as cable filling and cable flooding compounds.

Depolymerization

The heat of formation for polybutene is approximately -21.3 kcal/mole per degree of polymerization. Thus for Amoco H-300 (dp=22), ΔH_f°=-470 kcal/mole.

Polybutene is stable at room temperature but will depolymerize at high temperatures. The rate of decomposition for high molecular weight grades becomes significant at about 270°C and is quite rapid above 350°C. Although the thermal cleavage of the polymer backbone appears to be random, at sufficiently high temperatures the major product is isobutylene.

Oxidation

At moderate temperatures, polybutene offers considerable intrinsic resistance to air oxidation. As previously seen, the stability of Amoco polybutene has been used to an advantage in the manufacture of high quality sealants and caulks, electrical insulating fluids and lubricants.

Polybutene is flammable and should be kept under an inert gas blanket when in tank storage. Additional precautions are listed in Bulletin 12-38, available from your Amoco sales representative.

Amoco polybutene contains no antioxidants but they are recommended when color or odor requirements are stringent. Several hindered phenols have proven useful at concentrations of 0.01 to 0.10 wt.%. The antioxidant may be added by first preparing a 10 wt.% concentrate in polybutene at 95°C and then mixing this concentrate into the remaining polybutene.

Emulsion Technology

Recent Amoco research has demonstrated that stable polybutene emulsions can be formulated using any grade of Amoco polybutene and a variety of anionic, cationic and nonionic surfactants. This work offers particular potential in facilitating reduction or elimination of solvents in formulating metalworking lubricants, adhesives, wood and concrete sealers, fiber finishes and other applications. While less viscous grades are more easily stirred and handled, high molecular weight grades offer equivalent emulsion stability and water extendibility.

Emulsions of polybutene are generally prepared by blending the surfactant with polybutene in a high shear mixer and then slowly adding water. Heavier grades of polybutene must be heated to obtain efficient mixing. Details of this work are available from your Amoco sales representative or through your nearest Amoco polybutene sales office.

Solubility

At room temperature, Amoco polybutene is miscible with hydrocarbon solvents such as hexane; with chlorinated hydrocarbons such as carbon tetrachloride, chloroform and trichloroethylene; with ethers such as diethyl ether; and with esters such as n-butylacetate. A partial list of room temperature solubilities for Amoco H-100, H-300 and H-1500 are provided in Table 5.

Polybutene is partially soluble in n-butanol and other weak polar solvents. Polybutene is insoluble at room temperature in strong polar solvents such as water, ethanol, isopropanol, acetone, methyl ethyl ketone and glacial acetic acid.

Solvent formulating maps (Figure 7), generated by plotting the solubility parameter versus the hydrogen bonding index, can be useful tools to readily determine compatibility based on similar data for other components in the formulation at a given temperature. These maps define an area inside which active solvents for the resin are located.

Table 5

Solubility of Polybutene[1] (ASTM D-3132)

Solvent	Solubility Parameter	Hydrogen Bonding Index	Amoco Polybutene H-100	H-300	H-1500
Diisopropyl Ether	6.9	6.6	S	S	S
n-Heptane	7.3	2.2	S	S	S
50% Diisobutyl Ketone/50% Diisopropyl Ether	7.4	5.9	S	S	S
Diethyl Ether	7.4	6.9	S	S	S
50% n-Heptane/50% Diisobutyl Ketone	7.6	3.7	S	S	S
25% n-Heptane/75% Diisobutyl Ketone	7.7	4.5	S	S	S
66.7% n-Heptane/33.3% n-Butyl Acetate	7.8	3.3	S	S	S
Diisobutyl Ketone	7.8	5.2	S	S	S
57% Diethyl Ether/43% n-Butyl Acetate	7.9	6.3	S	S	S
Cyclohexane	8.2	2.2	S	S	S
n-Butyl Acetate	8.5	5.4	S	S	B
40% Cyclohexane/60% Toluene	8.6	3.2	S	S	S
33.3% Diethyl Ether/66.7% 2-Ethylhexanol	8.8	8.2	S	S	S
Toluene	8.9	3.8	S	S	S
50% Toluene/50% Dioxane	9.4	4.8	S	S	S
2-Ethylhexanol	9.5	8.9	S	S	S
Methylene Chloride	9.7	2.7	S	S	S
Dioxane	9.9	5.7	I	S	I
2-Ethoxyethanol	9.9	6.9	I	I	I
Carbon Disulfide	10.0	2.2	S	I	S
50% Toluene/50% Acetonitrile	10.4	4.2	I	S	I
50% EGMEE/50% n-Amyl Alcohol	10.4	7.9	I	I	I
n-Butanol	11.4	8.9	I	I	I
66.7% n-Butanol/33.3% Dimethylformamide	11.6	8.2	I	I	I
50% Dioxane/50% Dimethyl Sulfoxide	11.7	5.4	I	I	I
Acetonitrile	11.9	4.5	I	I	I
Dimethylformamide	12.1	6.4	I	I	I
50% Ethanol/50% Dimethylformamide	12.4	7.7	I	I	I
Nitromethane	12.7	3.1	I	I	I
Ethanol	12.8	8.9	I	I	I
72% Dimethyl Sulfoxide/28% Ethanol	12.9	6.1	I	I	I
Propylene Carbonate	13.3	4.0	I	I	I
66.7% Methanol/33.3% Dimethylformamide	13.7	8.1	I	I	I
57% Methanol/43% Dimethyl Sulfoxide	13.9	7.8	I	I	I
Methanol	14.5	8.9	I	I	I
Propylene Glycol	15.0	9.4	I	I	I

[1] S = soluble; I = insoluble; B = borderline

P lymer c mpatibility

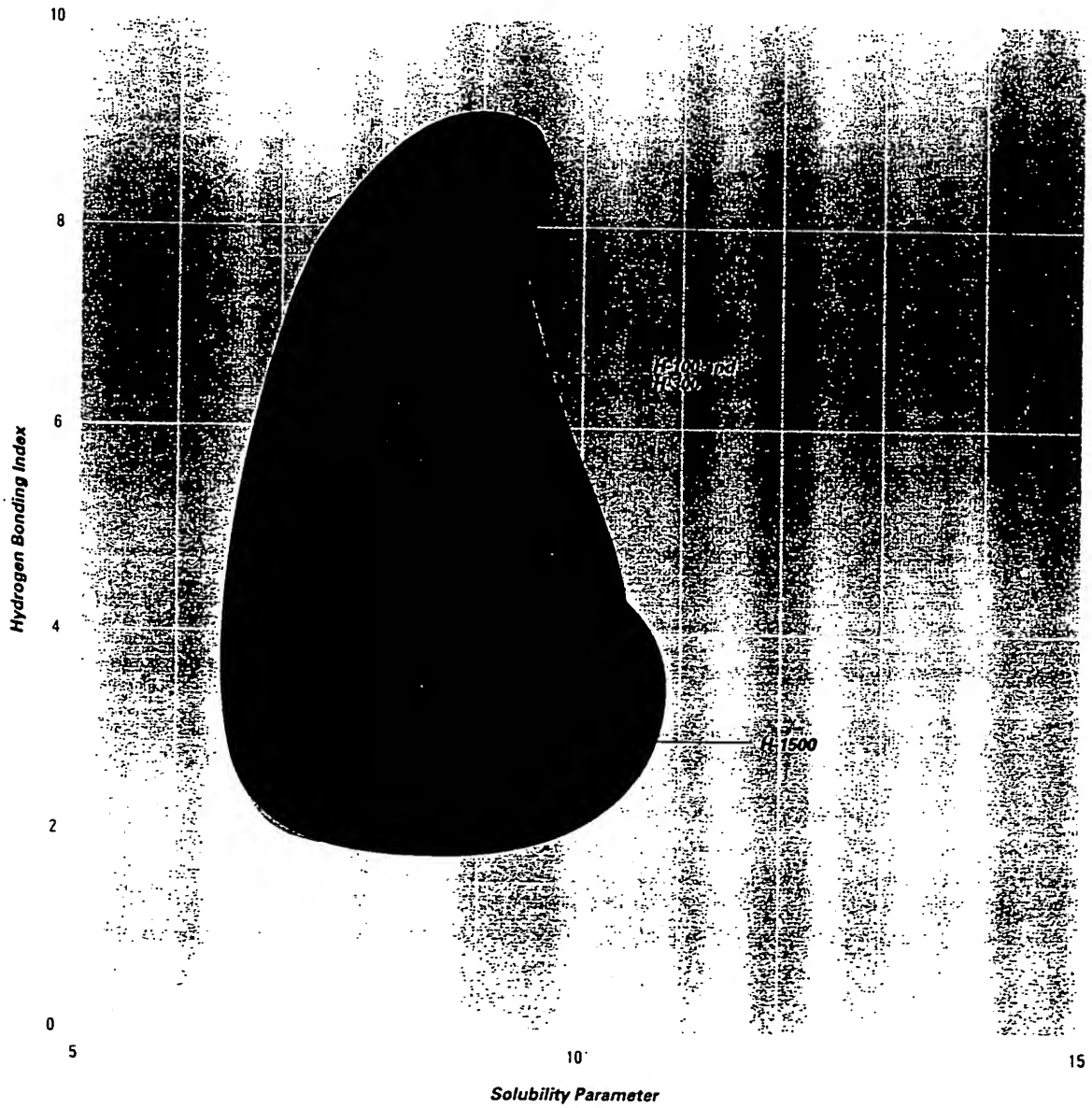
Many polymers are compatible with 50 percent or more polybutene. This is also true for a number of natural gums, rosins and derivatives, pitches, waxes and other natural products.

At lower concentrations, Amoco polybutene is compatible with most alkyds and modified alkyds, asphalts, chlorinated products, phenol condensation products and styrene copolymers.

Cellulose ester and alkyl celluloses are generally incompatible at concentrations above 10 percent.

FIGURE 7

Solvent formulating maps (@ room T°)



Color

Amoco polybutene is produced essentially water white. Color and haze are measured using a photometric method developed by Amoco. The electronic instruments used in the photometric method provide greater accuracy and sensitivity than is possible with an optical density unit (ODU) system.

The haze of a polybutene sample is measured by a nephelometer[1] which determines the amount of light scattered by the particulate matter in the sample. Results are reported in nephelometric turbidity units (NTU). The color of a polybutene sample is measured by a spectrophotometer.[2] Haze-free color is the amount of monochromatic light absorbed, corrected for the loss of brightness caused by haze.

Table 6 compares the photometric haze-free, APHA,[3] Saybolt and Gardner color scales. These values are approximations and may vary depending on the wavelength of the light source and light absorbance of the sample.

Amoco polybutene exhibits substantial color stability on long exposure to ultraviolet light and moderate heat. Polybutene is much more color stable than conventional mineral oils of similar APHA color. Extended storage of bulk quantities may require precautions to prevent color change, especially in lower viscosity material. Shipping, handling and storage procedures are outlined in Bulletin 12-38, available from your Amoco sales representative.

Mixtures with light colored pigments such as clay provide a striking example of the difference in color retention on exposure to light and heat. After aging, conventional mineral oils and clay look dirty while blends of clay and polybutene retain their original clean color.

Table 6

Color conversion

Photometric (haze-free)	APHA (visual)	Saybolt	Gardner
0	0	30	–
9	15	26	–
19	30	22	–
26	45	17	–
38	60	12	1
44	70	9	1
50	80	6	1
63	100	–3	1
94	150	–17	1
125	200	–37	1

[1] *Hach* 18900 ratio turbidimeter, trademark of Hach Company
[2] *Spectronic* 20 spectrophotometer, trademark of Bausch and Lomb Company
[3] American Public Health Association

Viscosity

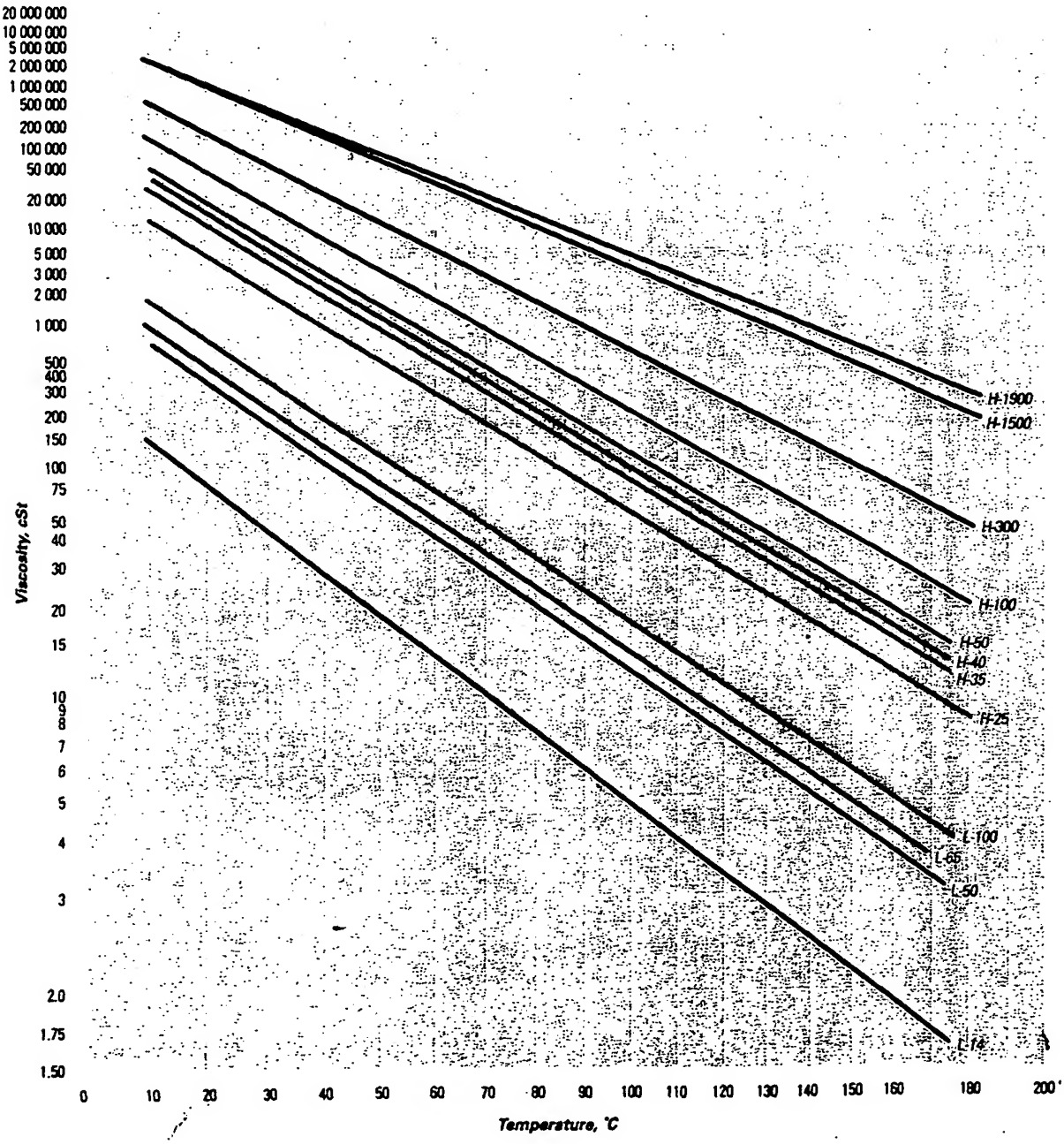
The viscosity-temperature charts (ASTM D341) for Amoco polybutene are shown on these pages. Figure 8 displays viscosity in centistokes (cSt) while Figure 5 shows viscosity in Saybolt Universal seconds (SUS). Conversion to centipoise (cP) from (cSt) is obtained by multiplying the viscosity in cSt by the density at the temperature under consideration:

$cP = cSt \times \text{density } (Kg/L)_T$.

Two grades of Amoco polybutene may be blended to produce a product with an intermediate viscosity. The instructions for accurately predicting the volume proportions of the two components are given in ASTM D341 and are paraphrased below.

FIGURE 8

Viscosity of Amoco polybutene in centistokes



1 On Figure 8 or 9, find the point (Point C) at th desired viscosity and temperature combination.

2 Draw a horizontal line through this point.

3 Choose a grade of polybutene with a lower viscosity (Point A) and one with a higher viscosity (Point B) than the desired blend.

4 The ratio of the line length AC to AB is the volume proportion of the higher viscosity grade required for the blend.

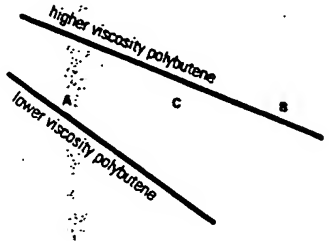
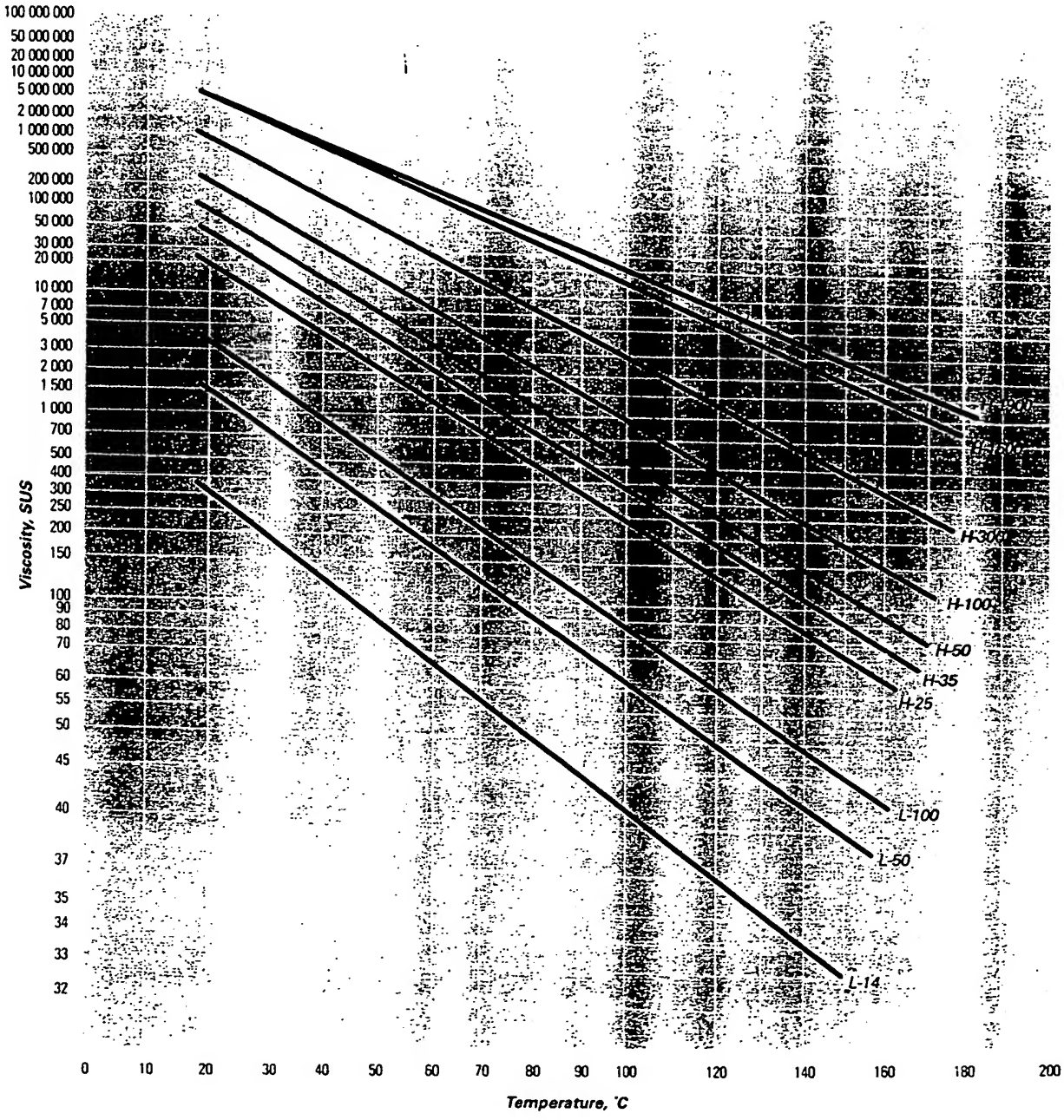


FIGURE 9

Viscosity of Amoco polybutene in Saybolt universal seconds



Density

At room temperature, the specific gravity of Amoco polybutene ranges from 0.83 to 0.90 depending on the grade. As can be seen in Table 7, density increases with rising molecular weight. (Data for other grades of Amoco polybutene are listed in the Table of Properties provided inside the back cover of this publication or are available from your Amoco polybutene sales representative.) Figure 10 shows how specific gravity declines with increasing temperature.

Thermal pr perties

The thermal conductivity of Amoco polybutene is about 0.066 Btu/hr-ft-°F at 40°C. For the higher molecular weight grades of polybutene, the conductivity at 150°C rises as much as 15 percent (0.076 Btu/hr-ft-°F). Data for selected grades of Amoco polybutene (ASTM D2717) are shown in Table 8.

The heat capacity of polybutene at room temperature is about 0.51 Btu/lb-°F (2100 J/kg-K), approximately half that of water. The specific heat increases at higher temperatures. Higher molecular weight grades generally exhibit a greater specific heat increase with temperature rise than lower viscosity grades. Specific heats for selected grades of Amoco polybutene (ASTM D2766) are shown in Table 9.

Table 7

Density of Amoco polybutene

	Specific gravity
L-14	0.830–0.845
H-100	0.882–0.898
H-300	0.887–0.904
H-1500	0.893–0.910

Table 8

Thermal conductivity of Amoco polybutene

	Btu/hr-ft-°F		
	100°F	200°F	300°F
L-14	0.066	0.064	0.065
H-100	0.066	0.068	0.071
H-300	0.065	0.066	0.069
H-1500	0.066	0.071	0.076

Table 9

Specific heat of Amoco polybutene

	100°F	200°F	300°F	350°F
L-14	0.55	0.58	0.60	0.61
H-100	0.53	0.55	0.57	0.58
H-300	0.51	0.58	0.65	0.69
H-1500	0.51	0.56	0.61	0.63

FIGURE 10

Effect of temperature on specific gravity of Amoco polybutene

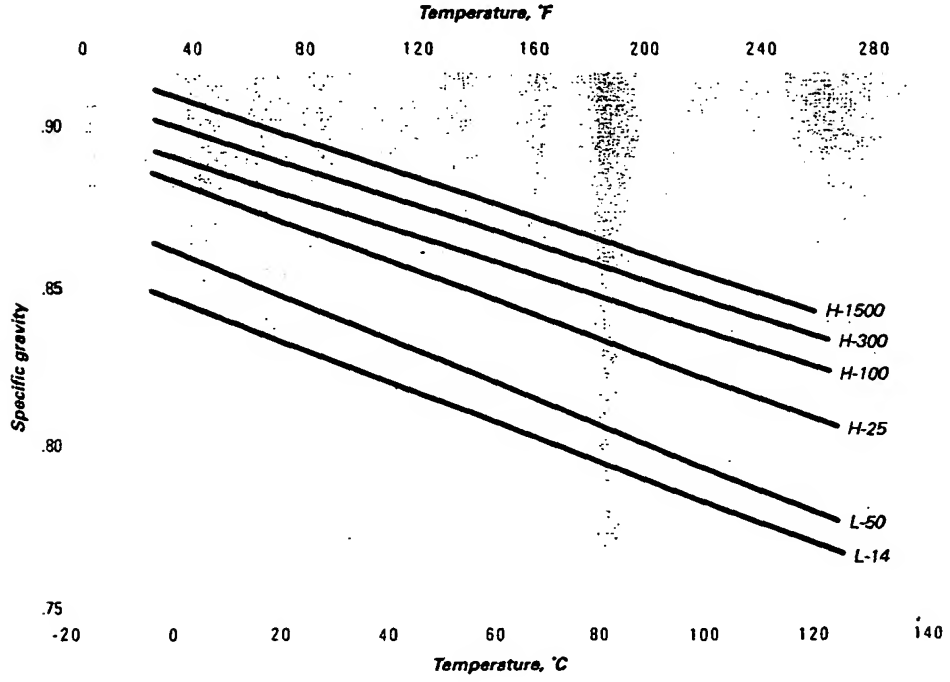


Table 10 shows that polybutene, with its highly substituted structure, has a low glass transition temperature and a low pour point. Pour points for other grades of Amoco polybutene are listed in the Table of Properties provided inside the back cover of this publication or are available from your Amoco polybutene sales representative.

Molecular weight range

The molecular weight distribution of several grades of Amoco polybutene, shown in Figure 11, were obtained from an analysis of the specific samples using a Waters 200 gel permeation chromatograph with columns having nominal exclusion limits of 30,000; 1000; 250; and 45 Å. The number average molecular weights of these grades are given in Table 11.

Although polybutene begins to decompose at temperatures above 270°C (520°F), a simulated distillation curve can be created using gas chromatography, as shown in Figure 12.

Table 10

Pour point and glass transition point of Amoco polybutene

	Pour point, °C	T_g[1], °C
L-14	–51	–90.5
H-100	–7	–69.6
H-300	+2	–66.9
H-1500	+18	–64.6

[1] Glass transition temperature by differential scanning calorimeter, 20°C/min in N_2.

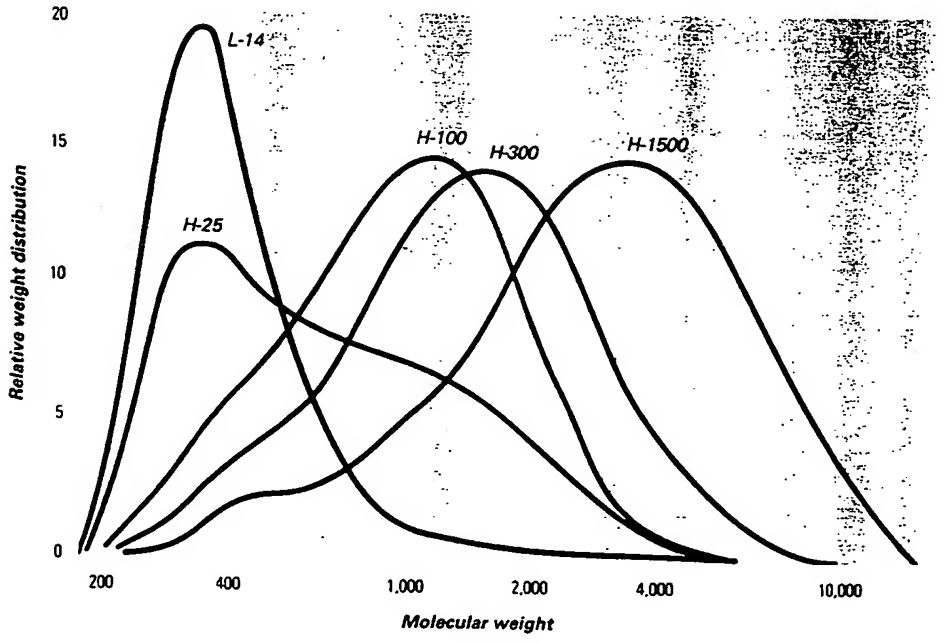
Table 11

Average molecular weight of Amoco polybutene

	Average molecular weight
L-14	320
H-25	610
H-100	920
H-300	1290
H-1500	2060

FIGURE 11

Molecular weight distribution of Amoco polybutene



Vapor pr ssure

The low vapor pressure of Amoco polybutene at temperatures below 100°C was inferred by the simulated distillation curve in Figure 12. A plot of these vapor pressures are illustrated in Figure 13.

Evaporation losses are extremely low for the more viscous grades of Amoco polybutene. Figure 14 shows evaporation losses determined using an isoteniscope (ASTM D972). Lower viscosity grades of polybutene show somewhat greater evaporative losses than do conventional mineral oils of the same viscosity.

Flash point and fire point data for various grades are shown in Table 12.

Table 12
Flash point and fire point of Amoco polybutene

	Flash point COC, °C	Fire point COC, °C
L-14	138	154
L-100	141	166
H-100	193	232
H-300	227	274
H-1900	243	307

FIGURE 12
Simulated distillation curves for Amoco polybutene

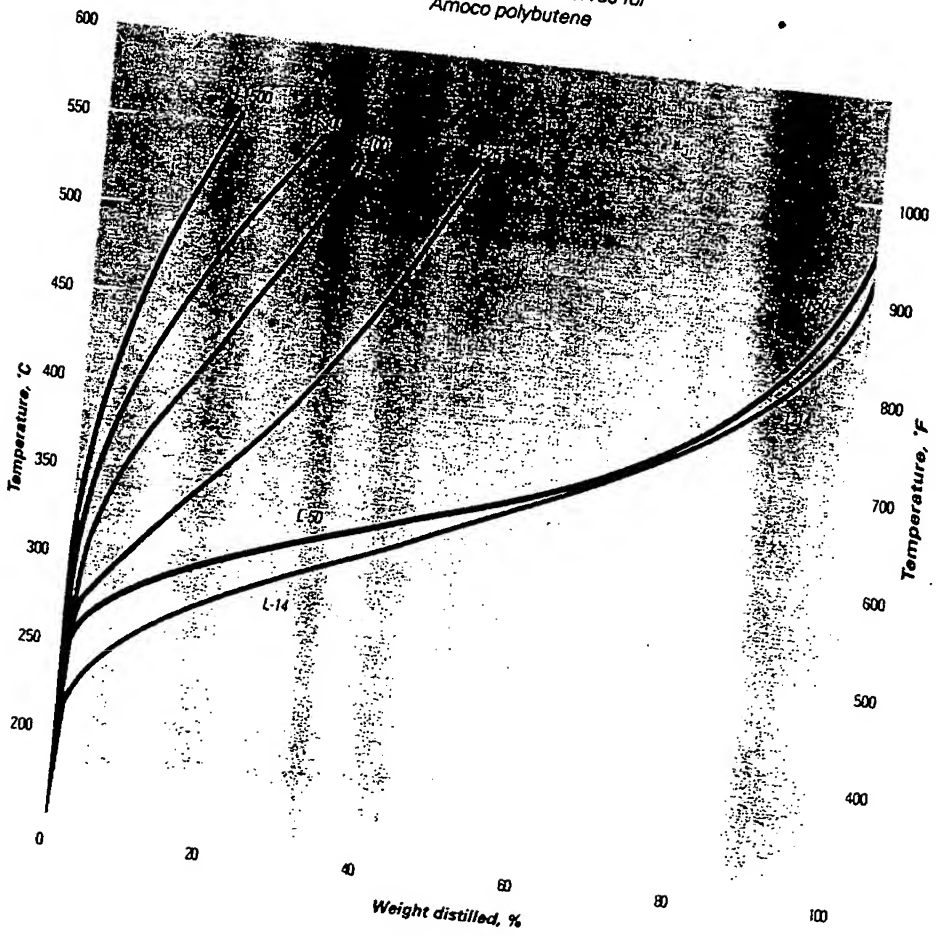


FIGURE 13

Vapor pressure of Amoco polybutene

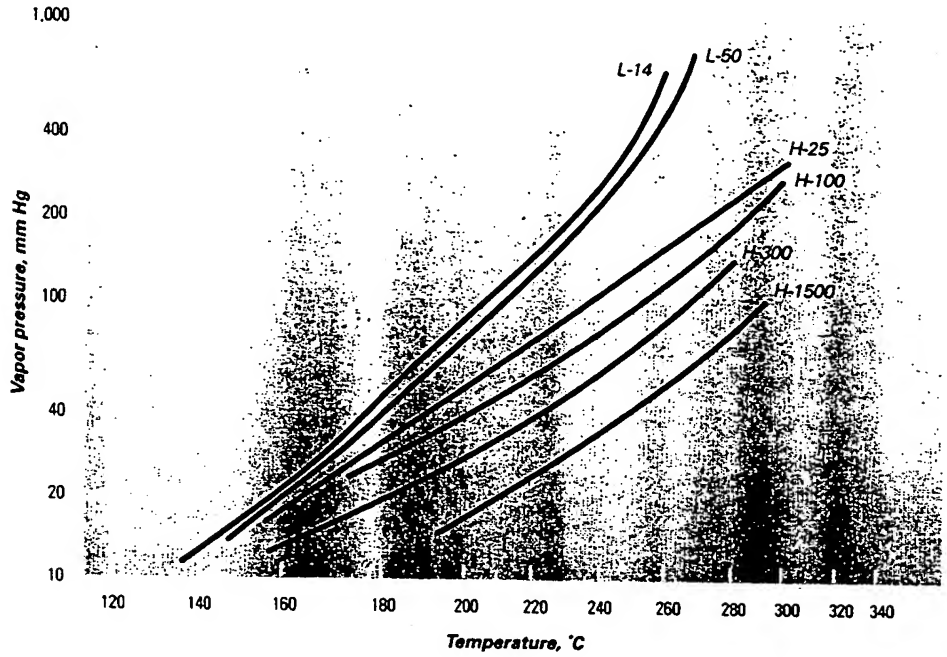
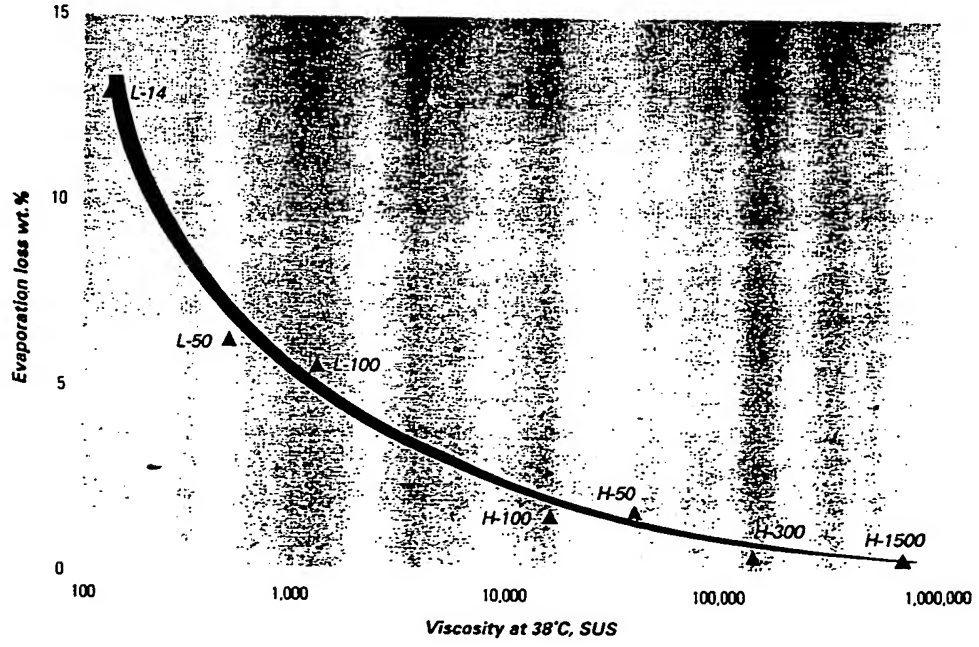


FIGURE 14

Evaporation loss for Amoco polybutene (10 hours at 99°C)



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Amoco Chemical Company

General Office

200 East Randolph Drive
Chicago, Illinois 60601-7125
Call toll-free 1 800 621-4557

Europe

Industrial Chemicals
15, rue Rothschild
1211 Geneva 21, Switzerland
Telephone (22) 715-0701

Asia

Industrial Intermediates
16th Floor, Great Eagle Centre
23 Harbour Road, Hong Kong
Telephone 852-586-8899

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